How much additional energy is available in the atmosphere for severe weather due to the 'greenhouse effect' and the 1 ^{0}C climate change in temperature over the last century?

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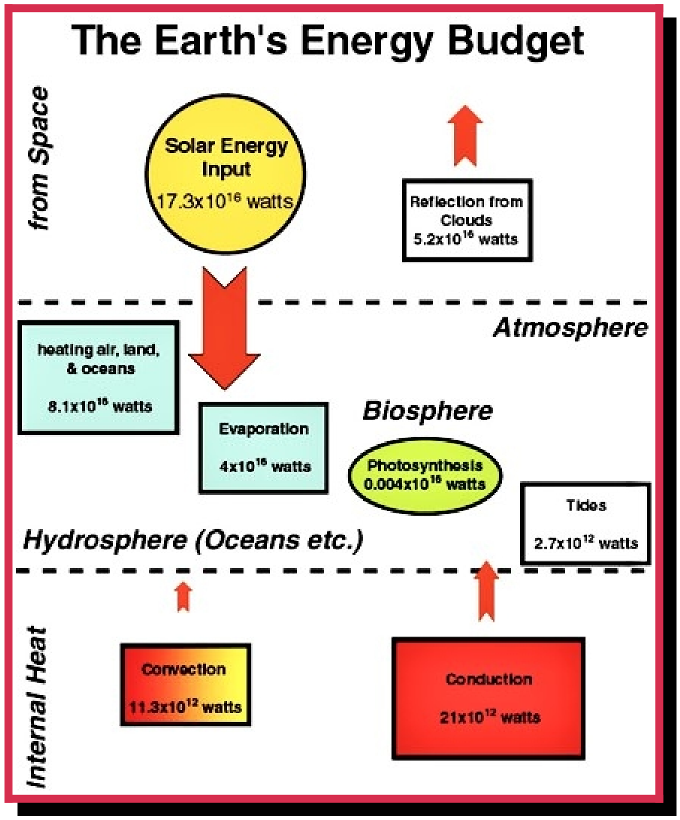

Figure 1. The total amount of energy that moves through the system is huge. It is on the order of 174 ,000 terawatts (1 terawatt = 1012 watts [energy per time]; 1 horsepower = 746 watts). Almost all of this energy comes to us via solar radiation. The Earth system receives 5000 times more energy from the sun than from the interior of the planet. Thus, although its manifestations are impressive (mountain ranges, earthquakes, volcanoes), the internal energy that keeps up mantle convection and drives the tectonic plates is only a small fraction of the energy that moves through the system. To put it into perspective, the total energy production by humans is about 9.6 terawatts at any given time. Thus, there is plenty of energy in the system. Even if humans were to extract all their energy needs from the solar input, there would still be plenty of energy left to keep the planet going.
This figure and text from Professor: Dr. Jürgen Schieber's Geology Notes at: http://www.indiana.edu/~geol105/1425chap4.htm

This is an attempt to give a scale to the atmospheric energy in the form of storms. The energy cycle in the air is outlined in figure 1. The effect of heating of the oceans and seas is not considered in these simple calculations. It appears that heating of the water on earth would also contribute to number and intensity of the various weather events listed here. This also does not assume that the water vapor in the atmosphere is part of these calculations. Clearly the heat capacity of wet air is higher than dry air. This means that the magnitude and number of weather events would be higher than the following simplified equations would imply.

First we look at the mass of dry air covering the earth and use this with the heat capacity of air to calculate the amount of steady state free energy available for weather events.

Calculation of Energy available in the atmosphere as a steady state increase of 1 degree C:

$M_{atmosphere} = 5 \times 10^{18}$ kg

$c_{atmosphere} = 1000$ J/kg ^{0}C [assuming dry air, moist air has higher values]

$\Delta T_{atmosphere} = 1\ ^{0}$C [due to 'greenhouse effect']

$E_{atmosphere} = (m_{atmosphere})(c_{atmosphere})(\Delta T_{atmosphere})$

$= (5 \times 10^{18}$ kg$)(1000$ J/kg ^{0}C$)(1\ ^{0}$C$)$

$= 5 \times 10^{21}$ J

This is the 'steady-state' additional energy in the atmosphere available for severe weather and other normal weather events. Lets look at how this could increase severe weather if all this energy was available for the following phenomena:

Lightning:

The average energy per lightning stroke is;

$E_{lightning\ stroke} = 1 \times 10^{9}$ Joules (J)

If all the energy is used for lightning we have a total number of;

$$N_{lightning\ strokes} = (5 \times 10^{21}\ J)/(1 \times 10^{9}\ J) = 5 \times 10^{12} \text{ lightning strokes}$$

This is 5 trillion or 5 000 000 000 000 additional lightning strokes worth of energy throughout the atmosphere at any instant.

Tornadoes:

The average energy per 2-minute duration tornado is;

$E_{tornado} = 1 \times 10^{11}$ J

If all the energy is used for lightning we have;

$$N_{tornados} = (5 \times 10^{21}\ J)/(1 \times 10^{11}\ J) = 5 \times 10^{10} \text{ tornadoes}$$

This is 50 billion or 50 000 000 000 additional tornadoes worth of energy throughout the atmosphere at any instant.

Thunderstorms:

The average energy per 30-minute duration thunderstorm is;

$E_{thunderstorm} = 3.6 \times 10^{13}$ J

If all the energy is used for lightning we have;

$$N_{thunderstorms} = (5 \times 10^{21}\ J)/(\ 3.6 \times 10^{13}\ J) = 1.4 \times 10^{8}\ \text{thunderstorms}$$

This is 140 million or 140 000 000 additional thunderstorms worth of energy throughout the atmosphere at any instant.

Hurricanes:

The average energy per 10-day long hurricane is;

$$E_{hurricane} = 5 \times 10^{19}\ J$$

If all the energy is used for lightning we have;

$$N_{hurricanes} = (5 \times 10^{21}\ J)/(\ 5 \times 10^{19}\ J) = 100\ \text{hurricanes}$$

This is 100 additional hurricanes worth of energy throughout the atmosphere at any instant.

Summary:

This is meant only to give a sense of how a 1 ^{0}C global temperature change from a century ago could actually impact severe weather around the world. This does not mean that these enormous numbers of events are or will occur only that the potential energy available for such events is enormous. It should be used with caution since there are many complex factors in the environment (such as those illustrated in Figure 1) that can tie up the energy and prevent the formation of these systems.

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Authors Note: As of Tuesday April 21, 2020, We have seen dramatic changes in the number and strength of storms and related energy events such as tornadoes, hurricanes, lightning and thunderstorms. The free energy in the environment due to the global heating provides a complexification of weather on other levels as well. The shape and intensity of storms as well as a more complicated patterns within such events means that they are not going to act like old large relatively homogeneous fronts or patterns. There is much more complexity of structure in weather patterns today making prediction of their evolution and damage capability much harder.